Performance of the Ethanol Fueled Four-Stroke Engine by using the Pressured Air Tubes and the Electric Fuel Pumps

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Abstract: This study presents the engine performance resulted from the use of ethanol fuel for a four-stroke fuel motor with a fuel injection system using pressurized air tubes and an electric fuel pump. Increase in the number of motorized vehicles has increased fuel consumption. This can increase gas pollutants that pollute the air. So that it is necessary to convert the use of fuel oil to an alternative fuel that is environmentally friendly and renewable, one of this is ethanol. Tests are carried out at 4000 rpm to 7000 rpm at 1000 rpm intervals and data retrieval in the form of torque, power and fuel consumption. The results have shown that at 4000 rpm to 5000 rpm engine speed using a pressurized air tube there is a 40% increase in torque from the original 5 N.m to 7 N.m. Engine speed of 5000 rpm to 7000 rpm, torque and power produced using a pressurized air tube is greater than that of an electric fuel pump. Using pressurized air tubes increases power and specific fuel consumption (SFC) as engine speed increases.

1 INTRODUCTION

In Indonesia, lately there are frequent fluctuations in the supply and price of fuel oil (BBM). Data from the 2013 oil and gas statistics center PT. Pertamina, conveyed by the managing director, Indonesia's crude oil production continued to experience a fluctuating decline from 1977 to 2014, while consumption continued to increase. This causes PT. Pertamina as a state-owned enterprise (BUMN) engaged in oil and gas production in Indonesia must import crude oil to meet national fuel needs. Indonesia's crude oil production is currently 65% of the total national demand while the remaining 35% is imported (Hardadi, 2015). This imbalance between production and consumption will have an impact on fluctuations in fuel supply and prices in Indonesia. In the past 4 years, from 2013 to 2016, there were 8 times changes in fuel prices on the market. Factors that cause fuel consumption in Indonesia are significant increase in the number of motorized vehicles and the lack of use of renewable energy. While fossil fuels or petroleum are fuels that are non-renewable, we must start looking for substitute fuels.

The use of fossil fuels also affects the negative impacts on the environment that cause global warming (Kartika and Kristanto, 2013). The issue of global warming which is a world issue current encourages several countries to implement go-green and renewable energy-based technologies in all industrial sectors, especially the automotive industry. So to overcome this we have to look for alternative fuels of many types and abundant and environmentally friendly, one of which is ethanol.

The use of ethanol as a fuel for gasoline engines (Otto) has been known since Henry Ford invented the vehicle in 1896. After the exploration and exploitation of petroleum began to be carried out by humans, fuel oil became the main and preferred fuel for gasoline vehicles (Otto). Although oil fuels dominate the use of gasoline motors, ethanol has become an alternative for the following reasons: (1) Oxygenated Octan Booster as a substitute for Tertiary Methyl Butyl Ether (MTBE) which is allegedly having a bad impact on the environment,

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(2) decreases exhaust emissions, and (3) reduce consumption of fuel oil (Setiyawan, 2012).

Global ethanol production for transportation fuels has tripled in 10 years, from 17 billion litres in 2000 to 86.9 billion litres in 2010, so that the total production of ethanol can be used as an alternative energy source to overcome fuel scarcity. The fuel system is a system that is very important and very influential on the performance of the motor fuel. On gasoline fuel and air motorcycles must be able to mix well before being burned by sparks from spark plugs. The fuel system has the main function of storing and distributing fuel and clouding fuel before it is inserted into the cylinder (Rahmadi, 2012).

The application of the Electronic Fuel Injection (EFI) system technology is expected to reduce exhaust emissions, produce maximum power and increase fuel efficiency (Nugraha, 2007). The engine used in this study will be applied as a car drive Kalisahak 28 that is energy-efficient cars fuelled by ethanol with the concept of city car. This car is used for energy-efficient vehicle competition where the vehicle must travel as far as possible by using energy to a minimum (more distance less energy) in accordance with the slogan of the Shell Eco Marthon Asia competition.

2 METHODS

The study process begins with preparations for the condition of the 4 cylinder fuel motor (Pardede and Sitorus, 2013; Sulistyo, 2011) that is not single cylinder which will be tested using ethanol fuel and pressurized air tube with a fuel injection system (fuel injection). The test carried out a comparison of the use of the pressurized air tubes with the electric fuel pumps in the fuel injection system against the performance of the engine produced. Engine performance observed in this test is torque, power, fuel consumption, and fuel efficiency.

The measurement of torque and power uses a dynamometer and measurement of fuel consumption using a measuring burette with a capacity of 25 ml and a stopwatch as a timer. Retrieval of these data is carried out at the same time.

The data collection procedures that will be carried out are as follows:

1. Using a Pressurized Air Tube

a. Raise the motorcycle (Table 1 and Figure 1) over the dynamometer (Figure 2) and tie it so it doesn't move forward or backward.
b. Install the engine speed sensor on the coil cable.
c. Refuel the 100 ml transparent tank to the maximum limit.
d. Install all components of the pressurized air tube system according to Figure 3 and set the pressure of the injector tube to 3.2 bar.
e. Adjust the engine speed so that it works at 4000 rpm.
f. Calculate the time for 20 seconds when the machine is working on a specified rotation.
g. Turn off the engine.
h. Save the test results data that appears on the Laptop.
i. Filling the fuel to the maximum limit of the tank with a burette so that the difference in fuel consumption used for 20 seconds in millilitres is recognized.
j. After all test data is obtained, and then repeat the testing procedure for engine speed from 5000 to 7000 rpm with multiples of 1000 rpm.

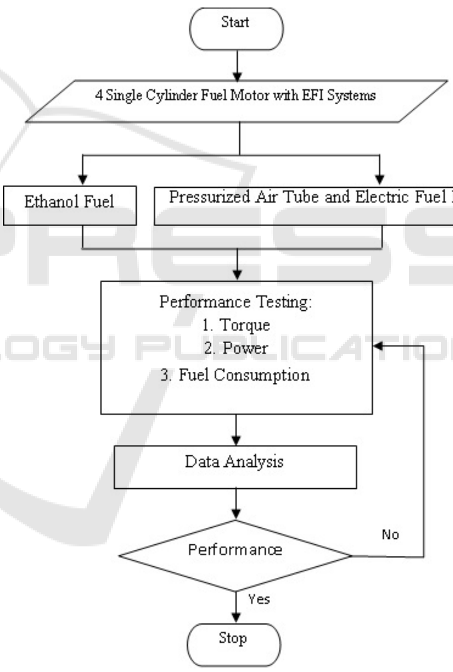

Figure 1: Flowchart of process study.

2. Using an Electric Fuel Pump

a. Raise the motorcycle (Table 1 and Figure 1) over the dynamometer (Figure 2) and tie it so it doesn't move forward or backward.
b. Install the engine speed sensor on the coil cable.
c. Filling in a measuring cup that uses the electric fuel pump (Figures 4 and 5) with a volume of ± 800 ml until the component of the fuel pump is submerged.
d. Turn on the engine and adjust the engine speed to 4000 rpm.

e. Calculate the time for 20 seconds when the machine is working on a specified rotation.
f. Turn off the engine.
g. Save test result data that appears on the monitor screen.
h. Remove the fuel pump from the measuring cup, then fill the measuring cup with fuel using a burette until the initial volume so that the difference in fuel consumption is used for 20 seconds in millilitres.
i. After all test data is obtained, and then repeat the testing procedure for engine speed from 5000 to 7000 rpm with multiples of 1000 rpm.

Table 1: Motorcycle engine test specification of Yamaha Mio J (PT. Yamaha Indonesia Motor Mfg., 2018)

Item	Standard
Engine type	4 stroke, 2 *Valve* SOHC, single cylinder
Diameter x stroke	54,5 x 57,9 mm (modification)
Cylinder volume	135 cc
Compression	13 : 1(modification)
Inlet Valve diameter	25 mm
Outlet valve diameter	21 mm
Fuel system	Fuel Injection, Single
Injector Type	Indirect Injector, 4 hole
Throttle Body	Single, *Std (Yamaha Mio Soul GT)
Fuel Injector Sensor	*Std (Yamaha Mio J)
Electronic control unit (ECU)	*Std (Yamaha Mio J)
Ignition system	Transistor Control Ignition (digital), Busi.
Cooling system	Air
Transmission system	Automatic Sprocket
Starter system	Electric Starter & Kick Starter
Fuel pump	Electrical Pump, (Yamaha Mio J).

Testing of the engine performance used the pressurized air tubes (Figure 3) as a substitute for the function of the electric fuel pump on the fuel injection system (Figures 4 and 5). A series of air tubes made of modified plastic bottles and added pressure regulator to regulate the pressure to the injector.

The fuel mass flow rate (Cengel and Boles, 1989) used equation (1) for calculation of the specific fuel consumption where fuel volume (V_f) in millilitre, ρ_f (fuel specific weight) in kg/m^3, and t (time) in sec.

$$\dot{m}_f = \frac{V_f \; x \; \rho_f}{t} \tag{1}$$

$$sfc = \frac{3600\, \dot{m}_f}{Ne} \tag{2}$$

Figure 1: Sample of test (motorcycle of Yamaha MIO J).

Figure 2: Dynamometer.

The specific fuel consumption (Cengel and Boles, 1989; Moran and Saphiro, 200)) in equation (2) is calculated for using the pressurized air tubes and the electric fuel pump respectively where the power (*Ne*) in kW.

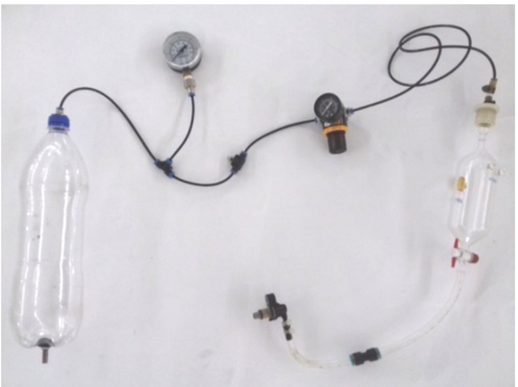

Figure 3: Components of pressurized air tubes.

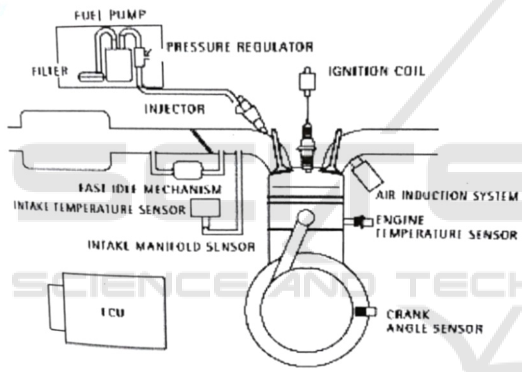

Figure 4: Electronic fuel pump system.

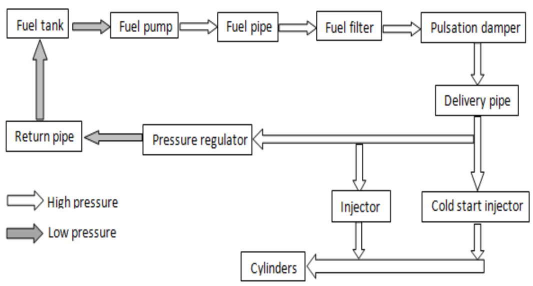

Figure 5: Fuel delivery scheme in electronic fuel pump system.

3 RESULTS AND DISCUSSION

Table 2 shows the effect of engine speed on torque, power, and fuel consumption by using pressurized air tubes for 20 seconds. Engine speed up to 5000 rpm, torque increases but after that the torque starts to decrease and fuel consumption continues to increase. Whereas power is increasing steadily with increasing engine speed and fuel consumption. When after 5000 rpm engine speed, torque begins to decrease due to the influence of pressurized air tubes that can reduce fuel when unused (Susilo and Nugroho, 2012).

Table 2: Effect of engine speed on torque, power and fuel consumption using pressurized air tubes.

Engine Speed (rpm)	Time (sec)	Electric Fuel Pump		
		Torque (Nm)	Power (kW)	Fuel Consumption (ml)
Idle	20	0.00	0.00	3.00
4000	20	6.00	2.50	5.50
5000	20	5.95	3.10	9.10
6000	20	6.10	3.85	10.20
7000	20	5.25	4.10	23.50

Table 3: Effect of engine speed on torque, power and fuel consumption using electric fuel pump.

Engine Speed (rpm)	Time (sec)	Pressurized Air Tube		
		Torque (Nm)		
Idle	20	0.00	0.00	1.40
4000	20	5.00	2.10	4.30
5000	20	7.00	3.70	8.30
6000	20	6.15	4.00	14.80
7000	20	5.90	4.25	17.90

Table 3 shows the effect of engine speed on torque, power, and fuel consumption using an electric fuel pump. At an engine speed of 4000-7000 rpm, torque fluctuates while power and fuel consumption increase respectively. The torque fluctuates due to the use of an electric fuel pump that functions to make fuel more economical, cleaner exhaust gas, and more perfect combustion of fuel and air (Hidayat, 2012).

Figure 3 shows a comparison of the specific fuel consumption between the use of pressurized air tubes and an electric fuel pump. Specific fuel consumption increases in the use of pressurized air tubes, while in the use of electric fuel pumps, it fluctuates. At engine speeds of up to 5000 rpm and

7000 rpm, the use of compressed air tubes is more economical fuel consumption compared to the use of electric fuel pumps. That's because the air pressure given by the use of pressurized air tubes is lower than the use of electric fuel pumps. In contrast, at 6000 rpm engine speed, the use of electric fuel pumps is more economical than the use of pressurized air tubes. That is because the air pressure provided by the electric fuel pump is lower than the use of pressurized air tubes. In principle, both uses function to regulate the fuel entering the combustion chamber according to the working conditions of the engine (KMHE, 2016).

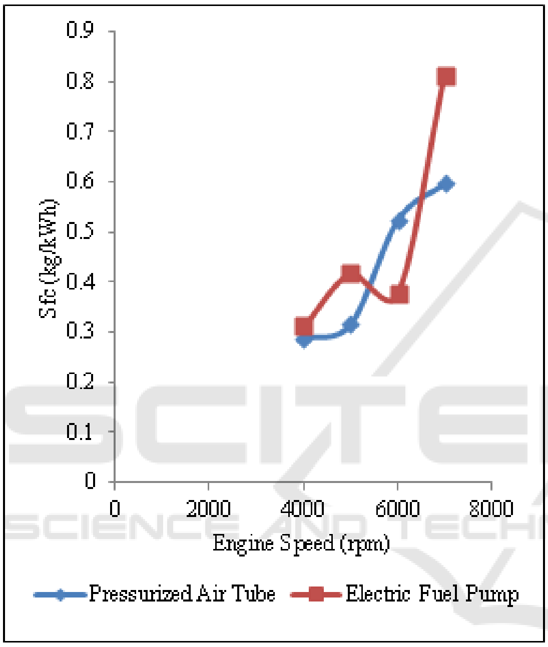

Figure 3: Comparison of specific fuel consumption using pressured air tube and fuel pumps.

Based on the results obtained in Table 2, Table 3, and Figure 3, it can be explained that the performance of the four stroke motor which uses pressurized air tubes is more efficient in consuming ethanol fuel than the use of electric fuel pumps, especially at 4000 rpm engine speed, 5000 rpm and 7000 rpm.

4 CONCLUSIONS

The performance of the engine produced by using the pressurized air tubes at engine speed of 4000 rpm to 5000 rpm increase torque of 40% and decrease at engine speed of 5000 rpm to 7000 rpm. Increased power and specific fuel consumption followed by increase engine speed. The use of electric fuel pumps for engine speed of 4000 rpm is more powerful than the use of pressurized air tubes. At engine speed of 5000 rpm to 7000 rpm where torque and power generated by using the pressure air tube is greater than that of an electric fuel pump. At 6000 rpm engine speed, the use of electric fuel pumps is more fuel efficient than pressurized air tubes. The performance of the 4 stroke fuelled ethanol engine is better by using the pressurized air tubes as a whole than by using the electric fuel pumps.

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